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Peer Review

Review of: "An Elementary Microscopic Model of Sympatric Speciation"

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Potential applications of an agent-based framework for studying resource-competition driven diversification - A review of: An Elementary Microscopic Model of Sympatric Speciation

The strength of this paper is the didactic presentation of an agent-based model of resource-competition driven diversification. Its novelty lies in the inclusion of resource dynamics and the explicit representation of resource competition with the aim of developing “a valuable didactic tool to teach evolution, adaptability, and ecology.” I completely agree with Sten’s evaluation of the quality of the model presentation. Besides, few agent-based frameworks study adaptive dynamics (see a structured bibliography here). Thus, I think that this framework may also provide an efficient research tool for studying specific ecological situations. The most similar modelling framework I found is presented in Getz et al. (2016).

The paper also describes a phenotypic model “to revise the advantages and drawbacks of the classical population dynamics approach.” However, these “advantages and drawbacks” are not discussed explicitly. I agree that it can be helpful to introduce the subject with a straightforward phenotypic population dynamic model and include an explanation of the common and different assumptions compared to the agent-based simulations. However, I would use a much simpler model (e.g., Pásztor et al., 2016 TBox 10.6 Evolutionary consequences of competition) just to be more didactic.

The paper uses the example of Darwin's finches as a “narrative theme.” I see an opportunity here to bring the interpretation of the model closer to the vast knowledge developed about “his” finches since Darwin’s discovery. The Galapagos archipelago provides a heterogeneous environment for life with its

 doi.org/10.32388/ZJCID1

geomorphologically varied volcanic islands of various ages. Speciation and adaptive radiation happened in the archipelago, not on a single island. There is no consensus about the mechanism producing diversification in this specific case and the significance of sympatric speciation in general (Stroud and Losos, 2020). The dominant view is that limited dispersal between the islands, adaptation to the local conditions, and divergence in songs (a mechanism contributing to reproductive isolation) are the first steps of the speciation process. Differences evolved in geographical isolation may be reinforced in sympatry. However, the universal role of competition is questioned even in the sympatric phase of evolution because the beak size distributions on the islands do not always support the hypothesis of character displacement or release (Grant and Grant, 2014; pp.20-21).

An interpretation of the agent-based modelling framework where each cell corresponds to different islands with independently renewing resources and limited dispersal of birds between them would better fit the natural situation. Developing the framework in this direction and relying on the tremendous amount of knowledge about beak size and seed size-dependent foraging efficiency, exceptionally close regression of the mass of bird populations on the mass of the available seeds, seed size and beak size distributions on various islands, etc. (Grant, 1999; Grant and Grant, 2014) could boost research into adaptive radiation across the Galápagos Archipelago as a whole.

Extinctions of species in formation must be frequent on these small islands. The paper mentions two related risks: the low supply rate of resources and the small population size. There are further risks worth studying. The vast fluctuations of weather conditions, i.e., in the supply rates, and slight differences between the regulating feedback loops of the emerging species. When the robustness of coexistence is small (Meszéna et al., 2006), then a slight change in the sensitive parameters will lead to competitive exclusion (Barabás et al., 2014).

As an author of textbooks, I also have some general comments. The paper provides formula-based definitions of general concepts like fitness. I would prefer to use the well-developed theory and terminology of adaptive dynamics. Resources are usually considered to be parts of a species' niche. In a niche theory that connects the niche concept to Darwin's "place in the economy of nature" metaphor and to the mathematical theory of robust coexistence, the niche space is defined by the regulating variables, and the niche of a species is given by the feedback loops controlling population growth. A resource that

can be characterized by a continuous variable represents a niche dimension that can be partitioned among species. The theoretical basis is given in (Meszéna et al., 2006), which we explained and illustrated with examples in chapter 10 of our textbook (Pásztor et al., 2016).

In conclusion, I believe that the paper opens up several directions for moving forward.

References

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Declarations

Potential competing interests: No potential competing interests to declare.